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BACKGROUND OF THE INVENTION

The present invention pertains to a sorption unit in accordance with the preamble of patent claim 1, to buffer means in accordance with the preamble of patent claim 19, to a condenser/evaporator unit in accordance with the preamble of patent claims 23 and/or 27, respectively, and to an air conditioning apparatus composed of these components, in accordance with the preamble of patent claim 37.

The aim of air conditioning rooms on one hand lies in the continuous air replacement and on the other hand in creating defined temperature and climatic conditions, i.e. regulation of air temperature, moisture and/or filtering of air. Air conditioning in the sense of the present invention in first place is a change in temperature either by an „air conditioning system“ for cooling, a heat pump system or another application.

In air-conditioning in terms of temperature presently e.g. methods are used in which the sorption action is initiated by cooling down a sorption part and an working medium is evaporated in an evaporator. The working mediums is exothermally absorbed in a sorption medium and in a subsequent endothermic reaction (regeneration phase) again is resorbed.

1 The apparatus used for realization of this method is described in
2 DE 42 33 062 and essentially consists of several elongated sorption ves-
3 sels (cooker absorber part) which over a part of their length are filled with
4 zeolite serving as sorption medium and in this part form an adsorber. The
5 other part of the length forms a condenser/evaporator zone (evaporator).
6 The sorption vessels are rotating in two coaxial housings on an orbit and
7 therein are located with the cooker absorber part in one housing and with
8 the evaporator part in the other housing. The housing enclosing the cooker
9 absorber parts comprises an entry and an outlet for a gaseous heat carrier
10 medium so that the heat carrier medium on its flow path through the
11 housing withdraws heat from the cooker absorber parts as well as supplies
12 heat thereto.

13
14 The cooker absorber part comprises elongated flat hollow bodies
15 bent in cross-sectional area, which are produced from high-grade steel
16 sheets of appx. 0.1 mm thickness, the surface of these sheets is smooth.
17 On the bottom sides, sheets bent in wave-like manner are arranged. On the
18 crest lines of the waves the sheets are mutually connected by rotary weld-
19 ing seams or by laser treatment. The sheets of about 600 mm length and
20 80 mm width are coated with zeolite, the zeolite layer during manufacture
21 being applied in a multiple layer coating process. The bends touch the
22 smooth high-grade steel sheet and thereby are supporting it. By this shape
23 channels are formed through which the water vapor is guided.

1
2 It is in particular the costly manufacture which results from the
3 fact that at first the sheet must be shaped and coated with zeolite, wherein
4 such coating may be carried out in one or in several layers. A further dis-
5 advantage has to be seen in the fact that the zeolite layer has to be applied
6 in thin layer, because zeolite is not a good thermal conductor and gas per-
7 meability of zeolite is not very good.
8

9 The major problem, however, results from the fact that the con-
10 nection between the sheet and the zeolite frequently is not permanent,
11 since the steel sheet during rotation passes hot and cold temperature zones
12 and consequently is subject to continually changing thermal expansion (e.g.
13 in the case when the sheets form the blades of a rotor). For this reason it
14 may occur that during operation zeolite layers become detached - either in
15 some areas or completely - so that the coating is destroyed, the channels
16 are blocked or the thermal transition is carried out ununiformly. In the
17 places where the zeolite layer is destroyed, the function of the sheets
18 and/or the rotor comprising the sheets is worsened.
19

20 A further aggravation of the air-conditioning apparatus results
21 from the problems in the evaporator area. The generic evaporator - as well
22 as the temperature insulation area between evaporator and sorption zone
23 (called buffer means) - include the problem that it is not avoided suffi-

1 ciently that during adsorption of the water in zeolite also larger water drops
2 are entrained by the evaporator to enter the sorption unit so that water
3 drops can enter the zeolite portion directly. This impairs efficiency of the
4 air-conditioning system, since the water drops have not absorbed heat from
5 the room surrounding the evaporator.

6
7 SUMMARY OF THE INVENTION
8

9 It is, therefore, the object of the present invention to further de-
10 velop the generic air-conditioning apparatus as well as its components in
11 such manner that a simple and cost-saving manufacture will result, wherein
12 the function of the apparatus and its components are to still be guaranteed
13 also after longer operation time.

14
15 The invention achieves this aim with respect to the components
16 sorption unit, buffer means and condenser/evaporator unit by the subject
17 matters of claims 1, 19, 23 and 27 and with respect to the apparatus - by
18 the subject matter of claim 37.

19
20 Preferred embodiments of the invention can be taken from the
21 subclaims.
22

1 The present invention creates a sorption unit for air-conditioning
2 and heat technology apparatus comprising sheets for heat dissipation, past
3 which a working medium is guided, said sheets being in contact with a
4 sorption medium forming string-shaped profiled bodies of such design that
5 the have flat contact with the sheets and that channels for passage of the
6 working medium are formed by means of the string-shaped profiled bodies.
7 As sorption agent e.g. zeolite can be used and as working medium - water
8 which evaporates in an evaporator and is adsorbed in the zeolite. Instead of
9 the matter combination water/zeolite also other combinations known per
10 se, e.g. ammonia/carbon, water/salt can be used.

11
12 In an embodiment of the invention the channels for passage of
13 the working medium are formed between neighboring profiled bodies. Pref-
14 erably, the profiled body at least to a high degree therein have the shape of
15 a double T or an X with closed top and bottom sides in order to create a
16 contact surface being as large as possible. These bodies then are used for
17 filling the space between double sheets. The profiled piece furtheron pref-
18 erably can be arranged in parallel with one another or can have different
19 lengths.

20
21 By the invention, areas of profiled pieces (e.g. zeolite) arranged
22 side-by-side or one behind the other are formed between the double sheets,
23 wherein in the area of constriction of adjacent double T pieces or of the X

1 pieces, respectively, without problem channels are formed for the passing
2 working medium (water) vapor,
3

4 The double T or X pieces furthermore are designed such that a
5 large-area contact area with the sheets is created, this resulting in good
6 thermal transition in these positions. Since zeolite has a comparatively poor
7 thermal conductivity, the area located at the inside is heated less, however,
8 this effect is of no importance because of the constriction.
9

10 In a further embodiment the channels for passage of the working
11 medium are formed in the profiled bodies and extend in longitudinal direc-
12 tion of said profiled bodies. Therein, the profiled bodies also are con-
13 structed such that a great contact area to the sheets is formed. Preferably
14 the profiled bodies have a square cross-sectional shape, wherein the chan-
15 nels preferably are arranged in the bodies with axial symmetry to the longi-
16 tudinal direction of the profiled bodies and have a circular or square cross-
17 section or a square cross-section with rounded corners. Preferably, in each
18 profiled body respectively one channel is arranged along the longitudinal
19 axis in the center of the cross-section of the body. However, a profiled
20 body can also comprise two, three or several neighboring sections with
21 square cross-sectional shape, wherein in each of these sections respec-
22 tively one channel along the longitudinal axis of the body, preferably in the
23 center of the cross-section of the section, is located. Like in the before-

1 described embodiment, the profiled bodies preferably can be arranged in
2 parallel with one another and have different lengths. The embodiment just
3 described therein provides the advantage that during insertion of the pro-
4 filed bodies between the sheets of the sorption unit due to the symmetry of
5 the profiled body no care has to be taken which sides of the body are in
6 touch with the sheets. This simplifies insertion of the profiled bodies.

7
8 As the front faces of the profiled piece in accordance with a fur-
9 ther embodiment of the present invention are not flat (e.g. broken), they
10 are not located one beside the other in sealing manner so that openings
11 and/or connections, respectively, between the are formed, which care for
12 uninhibited pressure balancing among the channels.

13
14 In accordance with a further particularly preferred embodiment of
15 the present invention a plurality of double sheet members are combined to
16 form a sorption/condenser evaporator package arranged one on top of or
17 beside the other, which can be adapted to most different purposes of use
18 in most simple manner by a corresponding geometric design and combina-
19 tion of device components. For example, the condenser output can be in-
20 creased by corresponding supplementary members and/or additional double
21 sheet layers without ado.

1 In a particularly preferred air-conditioning apparatus the con-
2 denser/evaporator unit and the sorption unit quasi are arranged one on top
3 of the other in a kind of compact system. The units therein are of layer-
4 shaped construction so that e.g. up to 100 „air-conditioning members“
5 each comprising an own sorption and condenser/evaporator units form the
6 complete air-conditioning system. In this case in accordance with the in-
7 vention a buffer zone and/or a buffer means, respectively, is located be-
8 tween the part of the sorption unit in which the zeolite chains are arranged
9 and the condenser/evaporator part preferably, said buffer zone and/or a
10 buffer means, respectively, preventing that heat emitted in the zeolite part
11 reaches the evaporator (if the evaporator serves for refrigeration).
12

13 In accordance with the present invention, said buffer zone is
14 provided with a water separation means which preferably has a construc-
15 tion of a plurality of sheets arranged in parallel with one another, each of
16 which having imprints on both sides, serving as spaces to the respectively
17 adjacent sheet and/or as collection recesses for moisture droplets. Said wa-
18 ter separation means is particularly advantageous since due to the ex-
19 tremely violent cooking operation in the evaporation phase due to the vac-
20 uum effect of the evaporator too large liquid droplets can be entrained with
21 the vapor streaming into the sorption unit, said droplets entering the zeolite
22 section of the sorption unit and thus reducing the output of the air-
23 conditioning system. This is prevented by the water separator in simple

1 manner in that the water separator more or less „catches“ the water drop-
2 lets and guides them back into the evaporator. Therein, the water separat-
3 ing effect is dimensioned such (by suitable dimensioning of the imprints)
4 that the output of the device is not reduced further, since the passage of
5 the water vapor to the sorption unit per se shall not be influenced nega-
6 tively. It is only the catching of larger-size water droplets that is desired. In
7 this area of the buffer zone the imprints also are bent upwardly or face
8 downwardly, respectively, on the later marginal areas in order that the
9 stirred water droplets are caught and guide back downwardly into the
10 evaporator. On the other hand, during the regeneration phase of the sorp-
11 tion unit expelled water vapor is to be permitted to condensate on the im-
12 prints and to flow down into the condenser/evaporator unit.

13
14 With respect to the condenser/evaporator unit the invention
15 reaches its aim by means of the subject matter of claims 23 or 27, respec-
16 tively. A condenser/ evaporator unit for air-conditioning and heat technol-
17 ogy systems is created, which also is characterized by liquid separation
18 means, a plurality of sheets arranged in parallel with one another being
19 provided for, each of which has imprints on both sides serving as spacers
20 to the respectively neighboring sheet and/or as collecting recesses for liq-
21 uid droplets. These imprints in simple manner impede passage of droplets
22 through the condenser/evaporator unit in downward direction and stabilize
23 the mutual position of the sheets.

1
2 In accordance with particularly preferred embodiments of the pre-
3 sent invention the imprints extend in bends curved downwardly so that
4 they form collecting cups and the mutual distance between the imprints
5 can be variable. The imprints furthermore can be bent further in the closer
6 vicinity of the sorption unit so that the can accommodate more water than
7 the lower spacers. This a/o. is advantageous because in this way a distri-
8 bution as uniform as possible across the entire condenser/evaporator unit is
9 effected (the amounts of water flowing to the sorption unit increase in di-
10 rection to the sorption unit). On its path to the sorption unit the vapor
11 thus quasi flows through kind of „labyrinth“ in which during streaming
12 about a corner or a bend water droplets in the water vapor are thrown
13 away due to centrifugal forces and get stuck on the water separator of the
14 buffer section or on the spacers of the condenser/evaporator unit so that
15 desirably the water is held back in the condenser/evaporator unit until it is
16 evaporated completely. During the regeneration phase in which the water is
17 expelled from the zeolite the imprints promote the condensation process
18 and guarantee uniform distribution of the water in the condenser/eva-
19 porator unit.

20
21 In advantageous manner the condenser/evaporator unit can also
22 be built as hollow body in which an inlay out of severely hygroscopic ma-
23 terial, like e.g. felt material or glass fiber material, can be inserted with

1 areal extension. In order to avoid that the fibers of the inlay sort out in
2 case of mechanical stress and sediment in the flow cross-sections, it is
3 provided for in advantageous manner that the material is supported on both
4 sides by support structures. These support structures can be formed by
5 sieve sheets e.g., which can comprise imprints for improvement of stabil-
6 ity. However, it is advantageous if these imprints are not facing the fibrous
7 material so that they do not cause densification of the material. If several
8 inlays are provided for in layers one on top of the other, it is advantageous
9 if these are spaced from one another by spacers. The spacers can be
10 formed by the support structure itself, wherein it is of advantage that this
11 support structure is made in the shape of a meander, zigzag or waves. For
12 stabilization of the spacers rib-shaped imprints or stampings, which are ar-
13 ranged on alternating sides and with a mutual distance can be provided on
14 the spacers in the sheet metal walls. In addition all sheet metal parts can
15 be surface treated for improvement of hygroscopic properties, wherein this
16 can be achieved by mechanical and/or chemical manner.

17
18 From the components sorption unit, buffer zone and con-
19 denser/evaporator zone in simple manner a compact, excellently working
20 apparatus of air-conditioning technology, a refrigerating apparatus or a heat
21 pump in particular, can be assembled.

1 Further scope of applicability of the present invention will be-
2 come apparent from the detailed description given hereinafter. However, it
3 should be understood that the detailed description and specific examples,
4 while indicating preferred embodiments of the invention, are given by way
5 of illustration only, since various changes and modifications within the
6 spirit and scope of the invention will become apparent to those skilled in
7 the art from this detailed description.

8
9 BRIEF DESCRIPTION OF THE FIGURES

10
11 The present invention will become more fully understood from the
12 detailed description given hereinbelow and the accompanying drawings
13 which are given by way of illustration only, and thus are not limitative of
14 the present invention, and wherein:

15
16 FIG. 1 shows a section of a sorption unit in accordance with the
17 present invention;

18
19 FIG. 2 shows a section of a further preferred embodiment of a
20 sorption unit in accordance with the present invention;

21
22 FIG. 3 shows a further section of the embodiment under FIG. 1;
23

1 FIG. 4 shows a section X-X' of FIG. 3;

2
3 FIG. 5 shows an embodiment of a section of a conden-
4 ser/evaporator unit and a buffer means in accordance with the present in-
5 vention in top view;

6
7 FIG. 6 shows a spatial view of the section of FIG. 5;

8
9 FIG. 7 shows a section A-A' of FIG. 5;

10
11 FIG. 8 shows a view of a „layer“ of an air-conditioning apparatus
12 in accordance with the present invention;

13
14 FIG. 9 shows a side view of the embodiment of FIG. 8;

15
16 FIGS. 10 to 13 are schematical cross-sectional views of further
17 embodiments of the condenser/evaporator unit in accordance with the pre-
18 sent invention, and

19
20 FIG. 14 shows a detailed view of the sectional view under FIG.
21 13 in perspective and enlarged representation.

22
23 DESCRIPTION OF THE PREFERRED EMBODIMENTS

1
2 a FIG. 1 shows a section ~~4~~ of a sorption unit 2 of an apparatus for
3 air-conditioning and heat technology in accordance with FIG. 9 including
4 sheets for heat emission past which water vapor is guided. Said sheets are
5 built as double sheets with sheet metal walls 3 and 3' which are connected
6 to one another at their ends (e.g. welded). String-shaped zeolite profiled
7 bodies 4 are arranged in the hollow chambers formed by sheets 3 and 3'.
8 These have a double T shape, wherein the top and bottom sides of said
9 a double T are in surface contact with said sheets 3 and 3'. In ~~an~~ ^{the} embodi-
10 ment of FIG. 2 corresponding facts are true for an „X“-shaped embodiment
11 of said zeolite body 4, wherein said top and bottom sides of said X bodies
12 are formed in closed manner in order to form a surface of contact as large
13 as possible.

14
15 The X bodies or double T bodies lying one beside the other, in the
16 area of their constrictions 5 form channels 6 respectively, through which
17 the vapor can pass. During manufacture of the elements 1 (which of course
18 should comprise not only three or four but a plurality of zeolite rows) it
19 only is taken care that „fragments“ are arranged in parallel with one an-
20 other.
21

FIGS. 3 and 4

As can be seen from *a* ~~FIG. 3~~, it is possible in simple manner to assemble several double sheet elements to form a package of sorption units located one on top and/or beside the other.

An essential advantage of this package of layer-like construction of sorption units has to be seen in that expensive zeolite coating of sheets 3 and 3' is not required. The zeolite pieces simply are put into the respective sheet hollow space and are shifted one against the next.

In the sorption unit and in the entire air-conditioning apparatus, respectively, preferably a pressure is maintained which is lower than atmospheric pressure. Thus the external pressure presses the comparatively thin sheets 3 and 3' against one another and the zeolite bodies are pressed against said sheets 3 and 3' and held in their positions.

FIGS. 5-8

a ~~FIGs 5, 6 and 7~~ show a condenser/evaporator unit 7 and a buffer section or buffer means 8. Above said buffer means 8 the passage to the sorption unit following in upward direction is somewhat constricted by sheet imprints 15. Thereby it is avoided that the profiled bodies can drop downwardly into said buffer means 8 in case of vertical alignment of the sorption unit 2.

1 The apparatus components sorption unit 2, buffer means 8 and
2 condenser/evaporator unit 7 (see FIG. 9) are formed as sheet pack, wherein
3 sheets 9a, 9b, 9c etc. each are in parallel with one another and are pro-
4 vided with stampings 10 and imprints 11, 14 on both sides. Said stampings
5 10 and imprints 11, 14 are arranged such that they develop a combined
6 effect as „flow passage labyrinth“, as „water collection pool“ and as me-
7 chanical „spacer“ of sheets 9a, 9b etc. Thus, a condenser/evaporator unit
8 7 and a buffer section 8 are created which are constructed in surprisingly
9 simple manner and nevertheless are highly efficient. In practical embodi-
10 ments e.g. between 50 and 100 sheets ^{9a, 9b} are arranged one beside the
11 other, depending on the desired cooling effect.

12
13 Thus, in the area of said buffer means - climatic separator - be-
14 tween said sorption unit 2 and said condenser/evaporator unit 7, respec-
15 tively, one water separation means 12 is formed for water drops of the wa-
16 ter vapor flowing to said sorption unit, which drops are entrained with the
17 water vapor or flow upwardly during cooking, so that they do not pass into
18 the sorption unit 2, this otherwise having caused a reduction of efficiency
19 of the air-conditioning apparatus. Or the imprints, respectively, are serving
20 as collecting cups for condensed water vapor in the regeneration phase of
21 the sorption unit. Said imprints 11 for this reason are bent downwardly in
22 the buffer zone 8 in order to stop the water droplets and to guide them
23 away in downward direction, whereas in the condenser/evaporator unit 7

1 they are bent upwardly in order to serve as collecting cups so that the
2 condensated water is uniformly distributed in the condenser/evaporator unit
3 and does not collect in the lower area only.

4
5 As can be seen from FIGs. 5, 6 and 9, the stampings 10 each can
6 be arranged across half of the sorption unit 2 and/or said con-
7 denser/evaporator unit 7, respectively, preferably on alternating sides and
8 complement with the stampings 10 of a second sorption unit and/or con-
9 denser/evaporator unit, respectively, positioned on said first sorption unit
10 and/or condenser/evaporator unit, respectively, to form a package. Said
11 stampings 10 therein in their mutual compensation serve as continuous
12 spacers across the entire width of the units and in this way in addition
13 form flow channels for guiding a ventilation and air flow from which heat is
14 extracted in the area of said evaporator 7 and/or in the area of said sorp-
15 tion unit 2 for absorption of heat from the exothermic process, in an air-
16 conditioning system. In contrast thereto, the air flow in the regeneration
17 phase of the air-conditioning systems in the area of said sorption unit 2
18 serves for emitting heat to the zeolite and for cooling during condensation
19 of the water in said condenser/evaporator unit 7.

20
21 As can further be taken from FIG. 7, said imprints 11 extending
22 from both sides into the evaporator 7 touch one another and in this way
23 serve as support for the two sheets against one another.

1
2 Said imprints 11 are straight in their lower area and are bent in
3 arc-shaped manner in the area of their rims and their distance increases in
4 direction to the sorption unit 2 in order to increase water separation effect
5 as result of the increasing vapor stream in direction to the sorption unit 2.
6

7 Said imprints 11 serving as spacers in the upper area of the
8 evaporator 7 can have a somewhat larger curvature so that the collected
9 amount of water there is greater than in the lower area of the evaporator 7
10 where the water condensate usually collects. In this way it is advanta-
11 geously achieved that during the cooking operation a distribution as uni-
12 form as possible, of the evaporated water across the entire evaporator
13 cross-section of the condenser/evaporator unit 7 is effected. On their bot-
14 tom side they can comprises edge-shaped guide fins caring that the water
15 is guided downwardly even in case of an inclination of the air-conditioning
16 apparatus (if it e.g. is arranged in a caravan driving on a sloping road or
17 subject to delay or acceleration processes).
18

19 For improvement of water distribution the condenser/evaporator
20 unit, the upper surface of the sheets can be roughened mechanically and/or
21 chemically.
22

FIG. 9 shows how a sorption unit 2 in accordance with the present invention, a condenser/evaporator unit 7 in accordance with the present invention and a buffer section 8 in accordance with the present invention can be combined to form a „layer-like“ and compact air-conditioning system consisting of individual storage members. Therein, the individual storage members are laid one on top of the other, the surfaces being kept at a distance by the stampings 10 serving as spacers. The cross channels formed by the spacers serve for guiding air ~~(see arrow 13 in FIG. 2)~~. Said channels have an essentially constant cross-sectional area so that an uniform air flow is created and the air in the evaporator area can be cooled uniformly. On the other hand the heat created during exothermic reaction in the condenser area of said sorption unit 2 is well guided away by the air stream.

Said condenser/evaporator unit 7 and said sorption unit 2 can be directly connected by said buffer section 8, as is shown in FIG. 9. It is, however, also conceivable that said condenser/evaporator unit 7 and said sorption unit 2 are in mutual connection through an elongated pipeline, wherein said pipeline itself can be built as condenser, in that corresponding cooling ribs are arranged on its outside so that the water vapor created in the expellation phase in which the water contained in the zeolite is expelled by heat supply and said sorption unit 2 is regenerated is condensated out in the area of the pipeline and returns into said evaporator 7 as water. It

1 also is possible to arrange a valve in said pipeline, by means of which the
2 connection between said evaporator 7 and said sorption unit 2 is closed
3 temporarily and only is opened when refrigeration is requested.
4

5 Alternative embodiments for the condenser/evaporator unit in ac-
6 cordance with the present invention result from FIGs. 10 to 14. The hollow
7 body of said condenser/evaporator unit consists of two sheet metal
8 semicups 15, 16 mutually connected on the edge e.g. by rotary welding,
9 between which an inlay 17 of severely hygroscopic material is received. As
10 said inlay is made from glass fiber material or felt material, a support struc-
11 ture 18 formed by a sieve sheet is provided for avoiding disintegration of
12 the fibrous structure because of mechanical stress. At the bottom side the
13 sheet metal cup 15 has rib-shaped stampings 19 serving as spacers for a
14 further condenser/evaporator unit.
15

16 The condenser/evaporator unit shown in FIG. 11 is formed similar
17 to the previous embodiment, but on both sides of the inlay 17 sieve sheets
18 18 are provided for, said sieve sheets each only extending across the
19 wave-shaped area of the respective sheet semicup, since the opposite side
20 of the inlay is covered by the sheet semicup itself. In addition, said spacers
21 19 are shortened in their longitudinal extension, but are arranged on alter-
22 nating sides on the surface of the respective sheet semicup 15' and/or 16',
23 respectively. The wave-shaped areas of said sheet semicups form channels

1 extending in longitudinal direction, through which the water vapor is pass-
2 ing.

3
4 In the embodiment in accordance with FIG. 12 two inlays 17 are
5 provided for which are kept on distance by means of a spacer 20. Said
6 spacer 20 can also be formed by a sieve sheet which is bent in essentially
7 meander shape. The sheet can also be bent in zigzag form, as shown in the
8 embodiment in accordance with FIG. 13, wherein imprints and stampings
9 21, 22 are provided for in the web area and in the respective support sur-
10 faces. Said imprints and/or stampings, respectively, serve for stabilization
11 of the comparatively thin-walled sheet. It is advantageous if said stampings
12 are not located in the area of the support surfaces of the inlays, as it is to
13 be avoided that the inlays are densified in these positions. Rather does the
14 stampings then extend in the space between said inlays or in the support
15 area to the direction not facing the inlay.

16
17 Of course, all sheets and support structures can be surface
18 treated for improvement of water absorption capacity, wherein this can be
19 done mechanically and/or chemically in the sense of a roughening. If the
20 sieve sheets in addition are manufactured from copper e.g., thermal con-
21 ductivity is essentially improved so that the grooves extending in longitudi-
22 nal direction also work as heat carriers.